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FUNDAMENTAL SKILLS TUTORING PROJECT, DAYTON, OHIO AREA

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13. ABSTRACT

The Intelligent Training Branch of the Technical Training Research Division of the Air Force Armstrong Laboratory developed a series of software packages to train high school students in Algebra, English and Life Science classes. The Alliance for Education was awarded a grant from Wright Laboratory to assist Armstrong Laboratory in its research by developing and maintaining local research sites in two Dayton-area high schools.

The Alliance for Education was tasked with selecting the schools, purchasing equipment, installing and maintaining hardware, supporting local teachers and administrators, and assisting Armstrong Laboratory personnel with implementation of their research program.

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1. Introduction

1.1. Background

The US Air Force Armstrong Laboratory at Brooks Air Force Base in San Antonio, Texas, is researching the application of the Air Force artificial intelligence technology in public schools through a series of computer-based tutors using Intelligent Tutoring Systems (ITS) technology

Wright Laboratory at Wright-Patterson Air Force Base signed a Memorandum of Understanding with all of the Air Force superlabs to support Armstrong Laboratory's research. Wright Laboratory then enlisted the assistance of the Alliance for Education and awarded the Alliance a grant to administer and implement the local component of the project.

The Alliance for Education is a nonprofit organization which is a coalition of industry, education and government, acting as a third-party advocate to improve education. The Alliance for Education is independent of local school districts but works closely with them. The Alliance for Education developed the title "Project F.A.S.T. Track" (Fundamental Academic Skills Training) for reference to the local component for this national project.

Wright Laboratory originally awarded the grant to the Alliance for Education in 1992 for one year with a renewal option for two additional years. Delays in software development at Armstrong Laboratory resulted in an extension of the project. This report covers the activities of Year Four and Five and reprises major events in each of the three previous years of the project. Refer to WL-TR-94-4023 for information concerning Year One of the project, WL-TR-95-4005 for information concerning Year Two and WL-TR-97-3808 for information concerning Year Three.

Activities for the first year involved site selection, site preparation, teacher training and support, provision of technical support, public relations and program evaluation. Activities for Years Two and Three involved research on the Algebra word problem solving tutor and an English reading and writing tutor, training additional teachers, retraining past teachers on operation of new versions of the software, installation of additional equipment, provisions for technical support, public relations, program evaluation and preparations for the Life Science tutor.

1.2. Definition of Terms

Artificial Intelligence (AI) Technology: Computer programs that attempt to achieve some type of intelligent behavior.

Intelligent Tutoring Systems (ITS) Technology: Application of artificial intelligence that enhances the power of computer-based instruction by acting like an expert private tutor.

ISIS (Instruction in Scientific Inquiry Skills): Life science tutor and the focus for Year Four research.

Maestro: Writing process tutor that is the revision of R-WISE and the focus for Year Five research.

R-WISE (Reading and Writing in a Supportive Environment): Reading/writing tutor used through Fall 1995; revised to become MAESTRO.

WPS (Word Problem Solving): Pre-algebra tutor and the focus of Year One research.

2. Local Project Objectives

I. To obtain research data on the effectiveness of the Intelligent Tutoring System (ITS) of the Fundamental Skills Training Program for Armstrong Laboratory by establishing regional testing sites

- Primary responsibility for the research rests with the Air Force Armstrong Laboratory in San Antonio, Texas. Wright Laboratory at Wright-Patterson Air Force Base signed a Memorandum of Understanding with all of the Air Force superlabs to support Armstrong Laboratory's research. Wright Laboratory then enlisted the assistance of the Alliance for Education and awarded the Alliance a grant to administer and implement the local component of the project.

- F.A.S.T. Track computer laboratories have been established and have been functional at Dayton Dunbar and Trotwood-Madison High Schools since 1992.

- The project collected data from both Dayton Dunbar and Trotwood-Madison High Schools and forwarded it to Armstrong Laboratory. It included

  ⇒ English and mathematics teachers' pre- and post-attitude surveys.

  ⇒ English students' on-line pre-and post-tests.

  ⇒ Mathematics students' on-line pre-and post-tests.

  ⇒ Science students' on-line pre-and post-tests.

  ⇒ Mathematics, science and English students' on-line journals and "thought logs" in which they recorded personal observations regarding lab activities and the tutors.

- In cooperation with Armstrong Laboratory, the local project research team conducted qualitative research involving science teachers and students.

II. To deliver an individualized instruction through transferring the technology of artificial intelligence applications to two public education systems in the Dayton area in

(a) a pre-algebra, word problem-solving tutor
(b) an English reading and writing tutor
(c) a life science tutor

- Each school lab contains 28 networked computer stations for students to use.

- In fall 1996 Armstrong Laboratory provided the Alliance with versions of ISIS and Maestro tutors for use in the Dunbar and Trotwood-Madison High School F.A.S.T. Track computer labs. The tested and revised WPS tutor was also available for student use.

- English teachers worked with students in preparation for their Maestro laboratory experiences. The skills were applied in four sequential areas of writing

  ⇒ *Prewriting* focuses on goal setting and planning. Tools include cubing (considering a topic from different perspectives), note taking, clustering (brainstorming ideas and grouping them logically) and outlining.

  ⇒ *Drafting* helps students take their organized ideas and compose sentences. This segment of the tutor provides for individual student differences by selecting one of three modes- -guided, supported or independent.

  ⇒ *Editing* stresses both revision and publication of students' work.

- Science teachers selected curriculum parallel modules to increase scientific inquiry skills as they pertain to ecological topics. Working through a personally designed, matrix students were challenged to

  ⇒ State a testable hypothesis

  ⇒ Design an experiment to test the hypothesis

  ⇒ Conduct the experiment simulated in the ecosystem

  ⇒ State a conclusion about the experiment

  ⇒ Accept or reject the hypothesis

III. To support school districts' efforts to increase student test scores on the Ohio Proficiency Test in mathematics, read and writing, and science.

- During Year Five local evaluators focused on two issues relating to this objective:

  ⇒ Correlation between Ohio Proficiency Test performance and the tutor usage;

  ⇒ Relationship between student performance, environment, technologies (both hardware and software) and student behavior.

- Trotwood-Madison High School teachers continued to use the WPS lab experience to support students who have not passed the mathematics portion of the OPT (Ohio Proficiency Test).

3. Alliance Responsibilities

I. ENSURE TRAINING AND SUPPORT FOR TEACHERS AND SITE COORDINATORS

- Held review and follow-up sessions with Trotwood-Madison and Dayton biology teachers, site coordinators, and a Dayton school district science specialist to supplement the ISIS training sessions held in San Antonio.

- Regularly communicated with coordinators and met periodically with teachers and district personnel to ensure adequate support. Forwarded information to Armstrong Lab.

- Reimbursed Dayton and Trotwood-Madison districts for the equivalent of one class period per day of each site coordinator's time to ensure adequate time to perform duties.

- Paid stipends to participating English and biology teachers and site coordinators in recognition of their additional responsibilities.

II. FACILITATE THE LOCAL PROJECT TEAM TO IMPLEMENT AND OVERSEE THE PROJECT GOALS AND ENSURE ADEQUATE STAFF AND TECHNICAL SUPPORT.

- Served as liaison for teachers, district administrators, and Air Force personnel at both Wright and Armstrong Laboratories to ensure research issues were addressed.

- Contracted with the University of Dayton Research Institute for the services of Katie Thorp, associate research engineer, to provide technical assistance to the project and to assist the local research team.

- Contracted with Select Tech Services, Inc. to ensure that qualified computer technicians were in the computer laboratories with teachers and students at all times for immediate resolution of any hardware or software problems or questions and to protect the integrity of the research.

- Submitted local status and technical reports and recommendations to Wright Laboratory regarding accomplishments and future direction.

III. ENSURE SITE AND EQUIPMENT NEEDS FOR THE RESEARCH ARE MET

- Continued to provide supervision for both the Trotwood-Madison and Dunbar F.A.S.T Track laboratories to effectively meet the needs of the ISIS and Maestro tutors.

IV. EFFECTIVELY ADMINISTER ALL GRANT FUNDS

- Flexibility provided by contracting for technicians' time resulted in significant savings.

- Costs to prepare school labs for Year Five were less than projected.

- During this extended research year less time than anticipated was required from the educational consultants.

- Publication and reporting costs were less than anticipated.

- No major maintenance or replacements of equipment were necessary during Year Five.

4. Summaries of Years One, Two, and Three

4.1. Summary of Year One (1992-1993)

During Year One of the project computer laboratories were constructed at Dunbar and Trotwood-Madison High Schools. Each laboratory contained 30 networked NCR 486 processor-based computers. Special student desks were designed and built to allow for maximum use of the space in the rooms and containment of wires and electrical outlets. The rooms were also equipped with controllable lighting and air conditioning to allow for maximum comfort and continuity between the test sites.

Armstrong Laboratory provided the labs with the first of the tutors to be developed. That tutor was called the WPS (Word Problem Solving) Tutor. The tutor was designed to teach ninth grade pre-algebra students word problem solving skills as well as general problem solving strategies with broader applications.

Armstrong Laboratory conducted research to compare the performance of students who used the tutor to similar students who did not. Armstrong Laboratory staff has published those results.

The local research team conducted student and teacher surveys to determine the general perception of the tutor. The teachers generally felt that the tutor had a positive impact on both their students and their own teaching abilities. In addition, the students generally reported a positive impression of the tutor.

4.2. Summary of Year Two (1993-1994)

During Year Two of the project, the R-WISE (Reading and Writing in a Supportive Environment) tutor was introduced to the labs. This tutor was designed to improve ninth grade English students' reading and writing skills by offering computerized tutoring specifically adapted to each student's performance level and interests. The tutor guided students as they practiced a logical sequence of steps including reading, comprehension, pre-writing, drafting, revision, and editing.

Armstrong Laboratory not only continued to conduct research on the WPS tutor but also developed a series of research questions for to the R-WISE tutor. For the R-WISE tutor Armstrong Laboratory compared the performance of students who used the tutor to students who used a simple word processor for an equivalent time and activity. Armstrong Laboratory staff have published those results.

The local research team conducted a series of focus group discussions with teachers and students involved in the project. Some frustration was expressed by the teachers with regard to the initial difficulty of learning the tutor and trying to instruct students when the teachers were not totally comfortable with the system. Both students and teachers stated that the tutors had a positive impact on the learning process.

4.3. Summary of Year Three (1994-1995)

Originally, Year Three was scheduled to be the year that the science-based tutor would be implemented. However, delays in the development of the science-based tutor required that implementation of that tutor be delayed by a year. Therefore, Year Three was termed a maintenance year for the two previously developed tutors. Minor software upgrades were made to those tutors, but no new activities were initiated.

Armstrong Laboratory continued to gather data on both of the tutors. Two versions of the R-WISE tutor were installed and compared to see how the differences impacted student performance. The difference in the tutors consisted primarily of the ways in which the students were given help during a session on the computer. One version of the tutor gave the students very directed help at numerous times during the writing process while the other version of the tutor provided help only when it was solicited by the students. Armstrong Laboratory will publish the results of this study.

Locally, the research activities of Year Three focused on the effect of the tutors on student ability to pass the Ohio Proficiency Test. Passing rates and scores for students who did and did not use the tutors were compared. No significant improvement in student pass rate of the math section of the Ohio Proficiency Test was seen for students who used the WPS tutor. Students who used the R-WISE tutor, however, showed a significantly higher passing rate on the writing section of the Ohio Proficiency Test than students who did not use the tutor.

5. Year Four as an ISIS Evaluation Year

5.1. Maintenance Year for WPS and R-WISE Tutors

Year Four was a maintenance year for both the WPS and the R-WISE tutors. Armstrong Laboratory continued to collect data from the English and mathematics classes using the tutors and to provide minor upgrades to the software.

5.2. Year Four Research Design for ISIS tutor

5.2.1. Description of the Tutor

In Year Four the third tutor, ISIS (Instruction in Science Inquiry Skills), was implemented at Dunbar and Trotwood-Madison High Schools. The primary goal of the ISIS tutor is to teach students the cognitive skills underlying the principles of scientific inquiry. Specifically, students will understand and demonstrate how to generate a hypothesis, design an experiment to test that hypothesis, conduct the experiment in a simulated ecosystem, draw conclusions about the experiment, and accept or reject the hypothesis based on those conclusions.

The second goal of ISIS is to address introductory high school biology in the area of ecology concepts and relationships. An understanding of these concepts will increase student potential for becoming scientifically literate, functional, and critical.

There are approximately 45 major domain concepts embedded in ISIS including biomes (e.g., grasslands, deserts, temperate deciduous forests), biotic factors (e.g., carbon dioxide, rainfall, sunlight), atmospheric conditions (e.g., greenhouse effect, pollutants), and ecological relationships (e.g., succession, symbiosis).

5.2.2. Research Design

There were no "non-treatment" group classes involved in the computer laboratories during Year Four. Instead, Armstrong installed two versions of the ISIS tutor and designed a series of research questions around the differences in these two versions. Essentially, one version had students enter into an idea mapping domain upon completion of an experiment. In that domain, the students were asked to draw cause and effect connections between ideas related to their problem. The other version of the tutor simply

did not contain this domain. Students immediately went on to another problem when they completed an assignement associated with an experiment.

5.2.3. Armstrong Laboratory's Role in the Evaluation

The project's primary research team, Armstrong Laboratory, administered a series of tests including attitudinal surveys and subject matter tests at the beginning and the end of the school year. Armstrong Laboratory personnel will publish their results when they are available.

5.3. Local Quantitative Research Project

In cooperation with Armstrong Laboratory and local school districts the local research team conducted a quantitative research project during Year Four. The purpose of this research activity was to determine the effect, if any, of the use of the tutors on the ability of students to improve their performance on and/or pass related sections of the Ohio Proficiency Test. This test is a ninth-grade level test administered state-wide. Passage of the test is required to receive a diploma upon graduation. Data relating to students who used either the WPS or the R-WISE tutors during the 1993-1994, 1994-1995, or 1995-1996 school years were included in the study. The study did not include information about students who used the ISIS tutor because there was not a relevant section of the Ohio Proficiency Test to use as an evaluation of usage of that tutor.

The local research team's report is attached as Appendix A.

6. Year Five as a Maestro Evaluation Year

6.1. Maintenance Year for WPS and ISIS Tutors

Year Five was a maintenance year for both the WPS and the ISIS tutors. Armstrong Laboratory continued to collect data from the science and mathematics classes using the tutors and to provide minor upgrades to the software.

6.2. Year Five Research Design for the Maestro tutor

6.2.1. Description of the Maestro Tutor

In Year Five Armstrong Laboratory implemented a significantly updated version of the R-WISE tutor which they renamed Maestro. The new tutor was more refined and integrated than earlier versions of R-WISE. The new version allowed development of ideas and writing samples to be expanded within the tutor and used in subsequent sections of the tutor for a smoother flow of ideas during the writing process.

6.2.2. ISIS Research Design

There were no "non-treatment" group classes involved in the computer laboratories during Year Five.

6.2.3. Armstrong Laboratory's Role in the Evaluation

The project's primary research team, Armstrong Laboratory, administered a series of tests including attitudinal surveys and subject matter tests at the beginning and the end of the school year. Armstrong Laboratory personnel will publish their results when they are available.

6.3. Local Quantitative Research Project

No local research activities were conducted during year Five.

7. Additional Activities

Examples of additional programs administered by the Alliance for Education and partially funded by the F.A.S.T. Track grant are ***Project GEMMA, Wright Connection***, and ***T^4***

Project GEMMA (Growth in Education through a Mathematical/Scientific Alliance) was designed in 1990 to provide experiences for high school teachers to explore science and mathematics in the world beyond the classroom walls. Nearly 100 teachers in Montgomery and Greene counties participated in summer internships at local business, industry or government sites where they actively took on "real world" work experiences designed to provide meaningful classroom transfer opportunities. Supported by a partnership of representatives from Dayton-area businesses, Wright Laboratory, schools/universities, the cornerstone of the project was one-on-one mentoring at local business and government sites, professional development seminars, strategies to transfer lessons learned to the classroom and academic-year dissemination activities.

Project Wright Connection is an expansion of Project GEMMA which began in 1995 when the National Science Foundation awarded over $2 million to the Alliance. A partnership among the Alliance, Wright Laboratory, area businesses, the Engineering and Science Foundation and Miami Valley schools, Wright Connection now provides opportunities for teachers in 14 counties to participate. The project continues to support meaningful summer internships as the cornerstone of learning. Many of the placement sites are at WPAFB.

Grants for classroom activities provide resources for educators to implement new techniques that address topics such as critical thinking, technology, scientific process and cooperative learning. Over 200 direct participants and hundreds of other school team members will benefit from Wright Connection as networks are established and teachers gain the skills necessary to prepare students for the future workplace.

T^4 was an initiative done in partnership with the Disney Celebration Teaching Academy to research Air Force technology applications in K-12 schools. Activities involved

- Ascertaining the current state-of-the-art technology used in education;
- Identifying effective technologies currently used in the areas of mathematics, science and reading/writing/communications education that can be advanced with an infusion of Air Force technology;
- Facilitating the initial steps of the infusion process by communicating the results of the study through production of a report upon the completion of research.

8. APPENDIX A - Ohio Proficiency Test Report

Fundamental Skills Tutor
Correlation with
Ohio Proficiency Test Data
for the 1993-1994, 1994-1995, and 1995-1996
School Years

Presented to the
Alliance for Education

January 10, 1997

Prepared by

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University of Dayton Research Institute

EXECUTIVE SUMMARY

Artificial intelligence based software programs have been developed by the US Air Force's Armstrong Laboratory to aid in teaching of the fundamental skills of writing and algebra word problem solving. These tutors have been field tested locally at Dayton Dunbar High School and Trotwood-Madison High School. The focus of this research was to determine the effect of tutor usage on student performance on the Ohio Proficiency Test (OPT).

Each of the tutors was addressed separately; and in each case the study population was limited to students who failed the math or writing portion of the OPT in the fall. The comparison of subscores between groups in the fall was then used to validate the statistical equivalence of the groups at the beginning of the school year. This does not, however, mean that the OPT is a valid test to measure student learning with the tutors.

There was a lack of any statistical significance in the passing rate on the OPT of the students who used the word problem solving tutor over those who did not, indicating that the software was not effective at helping students pass this important exam. There was, however, a significant improvement in passing rate for students who did not use the tutor in the Workshop classes at Trotwood-Madison over students in Workshop classes which did use the tutor. This could suggest that the tutor was not an appropriate teaching aid for this group of students. It could, however, simply be a reflection of the inability of OPT data to reflect learning accomplished through the use of the tutor.

Comparison of the subscores for the students who did and did not use the tutor suggested that the only area which showed an improvement of the tutor group over the control population was in the one area not believed to be addressed by the tutor (Data Analysis). These results further substantiate the suggestion that the word problem solving tutor is not an effective teaching aid for the material covered in the Ohio Proficiency Test.

Conversely, the results for the writing tutor were much more promising. There was a significant increase in the passing rate for the students who used the writing tutor over those who did not. This strongly indicates that the writing tutor software was highly effective at helping students pass this important exam.

Comparison of the subscores for the groups shows that the tutor group was able to improve their relative score from the lowest to the highest in the area of Content Organization. Likewise, the tutor group was able to at least remain equivalent to the other groups in the other subscore areas. The greatest help appears to be in the area of Content Organization which is the area most strongly addressed by the tutor.

Of course, other factors not controlled by the researchers can always affect the observed results. The fact that a large percentage of the control population came from another school may be a cause for concern. Likewise, differences in school curriculums, student populations, teacher experience and style, and mid-year updates of the tutors themselves could all play a part in affecting the results.

All of this analysis must be considered with the understanding that the Ohio Proficiency Test was not designed to be used as a measure of instructional techniques. In addition, a number of variables were not controlled in this comparison and could have had a significant impact on the results and conclusions. Furthermore, both tutors address a variety of material not evaluated by the OPT which could be of value to the students.

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1. Background

Several artificial intelligence-based software tutoring programs have been developed by the US Air Force's Armstrong Laboratory to aid in teaching the fundamental skills of writing (R-WISE), science (ISIS), and algebra word problem solving (WPS). Each of these tutors has been field tested at Dayton Dunbar High School and Trotwood-Madison High School as well as several other sites across the nation. The design of the R-WISE and WPS tutors suggests they may help students increase scores and pass the Ohio Proficiency Test (OPT). Through correlation of student usage of the tutor with OPT results, local researchers hoped to determine if the tutors were indeed an advantageous tool for preparation for this important exam. However, it should be noted that the tutors and Ohio Proficiency Test were not designed for use together. A lack of an improvement in OPT scores does not necessarily indicate that the students did not learn as a result of using the tutor. It could simply mean that the OPT is not the appropriate method of measurement for the effects of the tutors.

Ohio Proficiency testing in the field of science was not initiated until the spring of 1996 and as result, comparison of tutor usage and student performance was not posibile for that tutor.

2. The Word Problem Solving Tutor/OPT Analysis

This analysis includes data collected from Dayton Dunbar High School and Trotwood-Madison High School during the 1993-1994, 1994-1995, and 1995-1996 school years.

2.1. The Word Problem Solving Tutor

The WPS tutor is divided into a series of modules which address various topics. These modules were designed to be appropriate for the class materials covered in a general 9th grade Algebra course.

2.2. The Math Section of the OPT

The Ohio Department of Education has established a series of strands and learning outcomes which the math section of the Ohio Proficiency Test has been designed to measure. These strands and learning outcomes are listed in Table 1 and identified as to whether there are WPS tutor modules which address similar topics. Additional information about the mathematics learning outcomes is available in information published by the Ohio Department of Education.

Examples of test results from the math section of the Ohio Proficiency Test are given in Table 2. Each section of the Ohio Proficiency Test is scored on three levels. The first level is a pass/fail marking. A student who passes the test is not given any further scoring (i.e. score or subscores are omitted), and only a passing mark is returned to the school. A student who fails the math section of the test is then given a general score which can range from 0 to 199 given to three significant figures (i.e. 176, 180,...). The student is then given a subscore ranking in each of the five following strand areas: Arithmetic, Measurement, Geometry, Data Analysis, and Algebra. The possible subscore rankings are +, *, or – as defined in Table 2.

Through analysis of the goals and directives of the WPS tutor and the Ohio Proficiency Test, it was determined by the researchers that the WPS tutor did not directly address the issues evaluated in the Data Analysis subscore area. Therefore, the tutor would not be expected to increase student performance in this area. The other areas, however, were believed to be addressed by the tutor and should be affected by tutor usage.

2.3. Study Populations

The study population included only those students who failed the math section of the Ohio Proficiency Test in the fall of the year of study and for whom data was available for the spring test of that same year. Data were collected for the 1993-1994, 1994-1995, and 1995-1996 school years. The sample size for each population group and year are given in Table 3.

Table 1: WPS tutor modules and OPT mathematics strands.

OPT MATHEMATICS STRANDS	FOCUS OF WPS TUTOR
<u>Arithmetic</u> 1. Compute with whole numbers, fractions, and decimals 2. Compare, order, and determine equivalence of fractions, decimals, percents, whole numbers, and integers 3. Solve and use proportions 4. Round numbers to the nearest thousand, hundred, ten, one, tenth, and hundredth 5. Solve problems and make applications involving percentages	1. Yes 2. No 3. Yes 4. Yes 5. Yes
<u>Measurement</u> 6. Select and compute with appropriate standard or metric units to measure length, area, volume, angles, weight, capacity, time, temperature, and money 7. Convert, compare, and compute with common units of measure within the same measurement system 8. Read the scale on a measurement device to the nearest mark and make interpolations where appropriate	6. No 7. Yes 8. No
<u>Geometry</u> 9. Recognize, classify, and use characteristics of lines and simple two-dimensional figures 10. Find the perimeters (circumference) and areas of polygons (circles) 11. Find surface areas and volumes of rectangular solids	9. No 10. Yes 11. Yes
<u>Data Analysis</u> 12. Read, interpret, and use tables, charts, maps, and graphics to identify patterns, note trends, and draw conclusions 13. Use elementary notions of probability 14. Compute averages	12. No 13. No 14. No
<u>Algebra</u> 15. Solve simple number sentences and use formulas 16. Evaluate algebraic expressions (simple substitutions)	15. Yes 16. Yes

Table 2: Sample results for the math section of the Ohio Proficiency Test.

NAME	PASS or FAIL	SCORE	MEASURE-MENT	ARITH-METIC	GEOM-ETRY	DATA ANALYSIS	ALGE-BRA
Larry Student	Pass						
Mary Student	Fail	182	+	–	–	*	–
Carry Student	Fail	176	–	–	–	+	*
Berry Student	Fail	196	+	+	–	*	*

– = Performance lower than expected of students at the standard

* = Performance approximately the same as expected of students at the standard

+ = Performance higher than expected of students at the standard

Table 3: Number of students included in the WPS data analysis.

	WPS			Control			
	Dunbar Algebra	T-M Algebra	T-M Workshop	Dunbar Algebra	T-M Algebra	T-M Workshop	Total
93-94 School Year	82	55	20	33	0	0	190
94-95 School Year	38	37	72	103	53	52	355
95-96 School Year	71	0	37	103	0	55	266
School Total	191	92	129	239	53	107	
Group Total	283		129	292		107	811

2.3.1. Control

The control population included students who were enrolled in an algebra class which did not use the Air Force-developed software designed to enhance word problem solving proficiency. The control population would include students who were operating at class level, above class level, and below class level. For the purposes of this study, the control population was assumed to be equivalent to the treatment population. This assumption was enhanced by the fact that the study population was limited to students who failed the math portion of the Ohio Proficiency Test during the fall of the year in question.

2.3.2. WPS

The WPS population included students from Dunbar and Trotwood-Madison High Schools who were enrolled in an algebra class which used the WPS tutor. This group represents the experimental population in this study.

2.4. Data Analysis

In all cases, a Chi-Square analysis with a confidence interval of 5% was used to determine the statistical significance of the data. This indicates that if the numbers are statistically significant, then there is at least a 95% certainty that the same statistics would be observed in other, equivalent populations. Tabular representations of all of the data presented are included in Appendix A1.

For this analysis all of the treatment groups (Dunbar Algebra I Part I, Trotwood Practical Algebra, and Trotwood Workshop) were combined into one large treatment group, and likewise their representative control groups were combined into one large control group. This gave the largest sample size possible and should provide the most accurate statistics. Combining the groups should also show the effectiveness of using the tutor in general, with less affect arising from school curriculum differences, teacher styles, and class structure differences.

2.4.1. Comparison of Data Between Groups

By combining the data according to group, regardless of the year of study, a comparison can be made between the groups. This, then, can be used to determine the effectiveness of the tutor.

2.4.1.1. Fall

2.4.1.1.1. Pass/Fail Analysis

Due to the fact that the study population was limited to students who failed the OPT in the fall, no comparison can be made in this area.

2.4.1.1.2. Score Analysis

Due to the nearly continuous spread in the scores for the math section of the OPT, this analysis is complex and is not available at this time.

2.4.1.1.3. Subscore Analysis

Chi-Squared analysis of fall subscores showed no statistically significant variance in the groups. This indicates that the treatment and control groups were statistically equivalent at the beginning of the year. This enhances the validity of our comparison between these two groups.

2.4.1.2. Spring

2.4.1.2.1. Pass/Fail Analysis

This measure of the data gives the clearest representation of the effectiveness of the tutor at helping students pass the OPT. The goal of each student is to pass the test. An

increase in score may suggest an increase in ability, but without passing the test the students and schools do not measure any great improvement. When all three school years were combined, no statistically significant difference was measured between the passing rate of students using the tutor and those not using the tutor.

This suggests that use of the WPS tutor had no affect on student passing rates for the math section of the OPT. The lack of a difference in the passing rates could easily be attributed to other variables such as teacher differences, school curriculum variations, student population differences, and other non-controlled variables.

Similar comparisons were also made for each of the schools and courses independently. These comparisons again showed a lack of significance.

2.4.1.2.2. Score Analysis

Due to the nearly continuous spread in the scores for the math section of the OPT, this analysis is complex and is not available at this time.

2.4.1.2.3. Subscore Analysis

The Chi-Squared analysis of spring subscores showed a statistically significant variance only in the subscore category of Algebra. The other subscore categories did not show any significant difference between the treatment and the control populations. The area of algebra was believed to be addressed by the tutor, however, students who did not use the tutor appeared to do better in this subscore area. This could indicate that either the initial tutor goals were not properly identified, the OPT is measuring another difference between the study populations, or the tutor is not helping students in this area and the lost class-time is actually detrimental.

2.5. Results of WPS Tutor Analysis

Although a lot of data were collected and analyzed, the most relevant question to be answered relates to the effectiveness of use of the tutor to aid students with passing the

OPT. The fact that the study population was limited to students who failed the math portion of the OPT in the fall and that the comparison of subscores between groups in the fall suggest that the groups were statistically equivalent at the beginning of the school year suggest that this statistical comparison between students who did and did not use the tutor should be valid. It does not, however, mean that the OPT is a valid test to measure student learning with WPS. It will simply be an indication of whether students who used the tutor performed better on the OPT.

The lack of any statistical significance in the passing rate of the students who used the WPS tutor over those who did not indicates that the WPS software may not be effective at helping students pass this important exam. It could also, however, simply be a reflection of the inability of OPT data to reflect learning accomplished through the use of the tutor.

Of course, other factors not controlled by the researchers can always affect the observed results. Differences in school curriculums, student populations, teacher experience and style, and mid-year updates of the tutors themselves could all play a part by affecting the data analysis.

3. The R-WISE Tutor/OPT Analysis

This analysis includes data collected from Dayton Dunbar High School, Dayton Belmont High School, and Trotwood-Madison High School during the 1993-1994, 1994-1995, and 1995-1996 school years.

3.1. The R-WISE Tutor

The R-WISE tutor (Reading and Writing in a Supportive Environment) is divided into a series of tools which address various topics. Through observation and use of the tutor and analysis of some of the literature provided by Armstrong Laboratory on the objectives of the tutor, correlations were made between the writing characteristics and learning outcomes defined by the Ohio Department of Education for the OPT and the tutor itself. This comparison is shown in Table 4.

3.2. The Writing Section of the OPT

The Ohio Department of Education has established a series of characteristics and learning outcomes which the writing section of the Ohio Proficiency Test has been designed to measure. Table 4 lists the writing characteristics and related learning outcomes as defined by the Ohio Department of Education. During the 1995-1996 school year the area of Content/Organization was divided into two sections, making comparison between the three years inconsistent.

Table 4: OPT writing characteristics and R-WISE tutor objectives.

OPT WRITING CHARACTERISTICS	FOCUS OF R-WISE TUTOR
Content/Organization	
1. Conveys a message related to the prompt	1. Yes
2. Includes supporting ideas or examples	2. Yes
3. Follows a logical order	3. Yes
4. Conveys a sense of completeness	4. Yes
Language	
5. Exhibits word choice appropriate to the audience, purpose, and subject	5. Yes
6. Includes clear language	6. No
Writing Conventions	
7. Contains complete sentences and may contain purposeful fragments	7. No
8. Exhibits subject-verb agreement	8. No
9. Contains standard forms of verbs and nouns	9. No
10. Exhibits appropriate punctuation	10. No
11. Exhibits appropriate capitalization	11. No
12. Contains correct spelling	12. No
13. Is legible	13. No

Examples of possible test results from the writing section of the Ohio Proficiency Test are given in Table 5. The writing section of the OPT is scored on three levels. The first level is a pass/fail marking. A student who passes the test is not given any further scoring (i.e. score or subscores are omitted), and only a passing mark is returned to the school. A student who fails the writing section of the test is then given a general score which can range from 0 to 4.5 given in two significant figures (i.e. 3.5, 4.0,...). The student is then given a subscore ranking in each of the three following characteristic areas: Content/Organization, Language, and Writing Conventions. The possible subscore rankings are: satisfactory, needs some help, or needs help.

Table 5: Sample results for the writing section of the Ohio Proficiency Test.

NAME	PASS or FAIL	SCORE	ORGANIZATION	LANGUAGE	WRITING CONVENTIONS
Larry Student	Pass				
Mary Student	Fail	4.0	NH	NSH	S
Carry Student	Fail	3.5	NSH	NH	NH
Berry Student	Fail	4.5	NH	NH	S

S = Satisfactory

NSH = Needs Some Help

NH = Needs Help

Through analysis of the goals and directives of the R-WISE tutor and the Ohio Proficiency Test, it was determined by the researchers that the R-WISE tutor did not directly address the issues evaluated in the Writing Conventions subscore area. Therefore, the tutor would not be expected to increase student performance in this area. The other areas, however, were believed to be addressed by the tutor and should be affected by tutor usage.

3.3. Study Populations

The study population included only those students who failed the writing section of the Ohio Proficiency Test in the fall of the year of study and for whom data were available for the spring test of that same year. Data were collected for the 1993-1994, 1994-1995, and 1995-1996 school years. The sample size for each population group and year are given in Table 6.

Table 6: Number of students included in data analysis for each group and year for R-WISE analysis.

	R-WISE Dunbar	R-WISE T-M	WRITE Dunbar	WRITE T-M	Control Belmont	Control T-M	Total
93-94 School Year	25	44	19	12	53	42	195
94-95 School Year	36	111	0	0	77	0	224
95-96 School Year	93	96	0	0	0	0	189
School Total	**154**	**251**	**19**	**12**	**130**	**42**	
Group Total	**405**		**31**		**172**		**608**

3.3.1. Control

The control population included students who were not exposed to any Air Force-developed software designed to enhance writing proficiency. The majority of this population were students in the ninth grade at Belmont High School. However, some students in the control population were ninth grade students at Trotwood-Madison High School during the 93-94 school year who were not enrolled in a ninth grade English class which used the tutor. Because class rosters were not always available for classes which did not use the tutor, the remaining 9th grade population was used. As a result, students

who were enrolled in a class other than a standard 9th grade English class would be included in this population group. This could include students who were in honors level or remedial level courses. In either case, the control population would include students who were operating at class level, above class level, and below class level. For the purposes of this study, the control population was assumed to be equivalent to the treatment population. The accuracy of this assumption can be validated by comparison of fall scores and subscores on the Ohio Proficiency Test. This assumption is further validated by the fact that the study population was limited to students who failed the writing portion of the Ohio Proficiency Test during the fall of the year in question.

3.3.2. WRITE

The WRITE population included students from Dunbar and Trotwood-Madison High Schools who were enrolled in a standard 9th grade English class which used a simple word processor to assist in writing. The software did not contain any of the tutor assistance available in the more advanced version of the tutor. This group was used to study the effect of technology usage alone compared to the use of the more advanced tutor.

3.3.3. R-WISE

The R-WISE population included students from Dunbar and Trotwood-Madison High Schools who were enrolled in a standard 9th grade English class which used the advanced R-WISE tutor. This group represents the true experimental population in this study.

3.4. Data Analysis

In all cases, a Chi-Square analysis with a confidence interval of 5% was used to determine the statistical significance of the data. This indicates that if the numbers are statistically significant, then there is at least a 95% certainty that the same statistics

would be observed in other, equivalent, populations. Tabular representations of all of the data presented are included in Appendix A1.

3.4.1. Comparison of Data Between Groups

By combining the data according to group, regardless of the year of study, a comparison can be made between the groups. This, then, can be used to determine the effectiveness of the tutor.

3.4.1.1. Fall

3.4.1.1.1. Pass/Fail Analysis

Due to the fact that the study population was limited to students who failed the OPT in the fall, no comparison can be made in this area.

3.4.1.1.2. Score Analysis

The Chi-Squared analysis of fall scores showed no statistically significant variance in the data.

3.4.1.1.3. Subscore Analysis

Comparison of the fall subscores between groups could not be made in the area of Content Organization because of a change in the way the test was scored in the 1995-1996 school year. The other subscore areas showed that the groups were not statistically equivalent in the area of Writing Conventions.

In the area of Writing Conventions the R-WISE group appeared to perform the best prior to exposure to the tutor.

3.4.1.2. Spring

3.4.1.2.1. Pass/Fail Analysis

This measure of the data gives the clearest representation of the effectiveness of the tutor at helping students pass the OPT. The goal of each student is to pass the test. An increase in score may suggest an increase in ability, but without passing the test the students and schools do not measure any great improvement. No significant difference was measured in the passing rate for students who either did or did not use the tutor.

3.4.1.2.2. Score Analysis

The Chi-Squared analysis of spring scores showed no statistically significant variance in the data.

3.4.1.2.3. Subscore Analysis

Comparison of spring subscores by group showed statistical significance only in the area of Writing Conventions. In the fall subscore comparison of these two groups, they were not statistically equivalent with the R-WISE group performing slightly better. After exposure to computer-based training, this trend was still apparent. This area is not believed to be addressed by the tutor. Therefore, if the tutor is affecting scores, we would not expect it to affect them in this area

3.5. Results of R-WISE Data Analysis

Although a lot of data were collected and analyzed, the most relevant question to be answered relates to the effectiveness of use of the tutor to aid students with passing the OPT. The fact that the study population was limited to students who failed the writing portion of the OPT in the fall and that the comparison of subscores between groups in the fall showed no significant difference between groups, suggesting that the groups were statistically equivalent at the beginning of the school year. The lack of a significant

change in the passing rate of the students who used the R-WISE tutor over those who did not suggests that the tutor is not enhancing the ability of students to pass the OPT.

Of course, other factors not controlled by the researchers can always affect the observed results. The fact that a large percentage of the control population came from another school may be a cause for concern. Likewise, differences in school curriculums, student populations, teacher experience and style, and mid-year updates of the tutors themselves could all play a part in affecting the data analysis.

4. Conclusions

It appears that neither of the tutors is increasing student performance on the Ohio Proficiency Test. This analysis must be considered with the understanding that the Ohio Proficiency Test was not designed to be used as a measure of FST instructional techniques. In addition, a number of variables were not controlled in this comparison and could have had a significant impact on the results and conclusions. Furthermore, both of the tutors address material which is not evaluated by the OPT and which may of value to the students.

5. Appendix A1 - Tabulated Data

WPS TUTOR

Comparison of Data by Year

Fall Subscore Data

Measurement

	1993-1994	1994-1995	Total
–	154	285	439
*	34	65	99
+	2	5	7
Total	190	355	545

Arithmetic

	1993-1994	1994-1995	Total
–	155	285	440
*	32	59	91
+	3	11	14
Total	190	355	545

Geometry

	1993-1994	1994-1995	Total
–	53	180	233
*	118	148	266
+	19	27	46
Total	190	355	545

Data Analysis

	1993-1994	1994-1995	Total
–	113	210	323
*	69	125	194
+	8	20	28
Total	190	355	545

Algebra

	1993-1994	1994-1995	Total
–	110	228	338
*	70	119	189
+	10	8	18
Total	190	355	545

Spring Pass/Fail Data

	1993-1994	1994-1995	Total
Pass	22	60	82
Fail	163	295	458
Total	185	355	540

Spring Subscore Data

Measurement

	1993-1994	1994-1995	Total
–	113	195	308
*	47	91	138
+	3	9	12
Total	163	295	458

Arithmetic

	1993-1994	1994-1995	Total
–	142	227	369
*	15	58	73
+	5	10	15
Total	162	295	457

Geometry

	1993-1994	1994-1995	Total
–	57	132	189
*	86	135	221
+	19	28	47
Total	162	295	457

Data Analysis

	1993-1994	1994-1995	Total
–	93	208	301
*	62	85	147
+	7	2	9
Total	162	295	457

Algebra

	1993-1994	1994-1995	Total
–	105	118	223
*	57	159	216
+	0	18	18
Total	162	296	457

Comparison of Data by Group

Fall Subscore Data

Measurement

	WPS	Control	Total
–	248	191	439
*	50	49	99
+	6	1	7
Total	304	241	545

Arithmetic

	WPS	Control	Total
–	248	192	440
*	47	44	91
+	9	5	14
Total	304	241	545

Geometry

	WPS	Control	Total
–	128	105	233
*	154	112	266
+	22	24	46
Total	304	241	545

Data Analysis

	WPS	Control	Total
–	183	140	323
*	105	89	194
+	16	12	28
Total	304	241	545

Algebra

	WPS	Control	Total
–	183	155	338
*	110	79	189
+	11	7	18
Total	304	241	545

Spring Pass/Fail Data

	WPS	Control	Total
Pass	39	43	82
Fail	260	198	458
Total	299	241	540

Spring Subscore Data

Measurement

	WPS	Control	Total
–	177	131	308
*	79	59	138
+	4	8	12
Total	260	198	458

Arithmetic

	WPS	Control	Total
–	213	156	369
*	40	33	73
+	6	9	15
Total	259	198	457

Geometry

	WPS	Control	Total
–	106	83	189
*	122	99	221
+	31	16	47
Total	249	198	457

Data Analysis

	WPS	Control	Total
–	160	141	301
*	90	57	147
+	9	0	9
Total	259	198	457

Algebra

	WPS	Control	Total
–	137	86	223
*	110	106	216
+	12	6	18
Total	259	198	457

R-WISE TUTOR

Comparison of Data by Year

Fall Score Data

	1993-1994	1994-1995	Total
2	6	7	13
3	26	54	80
4	163	163	326
Total	195	224	419

Fall Subscore Data

Content Organization

	1993-1994	1994-1995	Total
NH	161	188	349
NSH	34	36	70
S	0	0	0
Total	195	224	419

Language

	1993-1994	1994-1995	Total
NH	136	141	277
NSH	44	63	107
S	15	20	35
Total	195	224	419

Writing Conventions

	1993-1994	1994-1995	Total
NH	120	128	248
NSH	42	53	95
S	33	43	76
Total	195	224	419

Spring Pass/Fail Data

	1993-1994	1994-1995	Total
Pass	58	78	136
Fail	137	146	283
Total	195	224	419

Spring Score Data

	1993-1994	1994-1995	Total
2	7	8	15
3	35	48	83
4	95	90	185
Total	137	146	283

Spring Subscore Data

Content Organization

	1993-1994	1994-1995	Total
NH	125	106	231
NSH	12	38	50
S	0	0	0
Total	137	144	281

Language

	1993-1994	1994-1995	Total
NH	97	71	168
NSH	26	48	74
S	14	25	39
Total	137	144	281

Writing Conventions

	1993-1994	1994-1995	Total
NH	76	74	150
NSH	29	31	60
S	32	39	71
Total	137	144	281

Comparison of Data by Group

Fall Score Data

	R-WISE	WRITE	CONTROL	TOTAL
2	2	1	10	13
3	43	1	36	80
4	171	29	126	326
Total	216	31	172	419

Fall Subscore Data

Content Organization

	R-WISE	WRITE	CONTROL	TOTAL
NH	190	22	137	349
NSH	26	9	35	70
S	0	0	0	0
Total	216	31	172	419

Language

	R-WISE	WRITE	CONTROL	TOTAL
NH	137	20	120	277
NSH	58	11	38	107
S	21	0	14	35
Total	216	31	172	419

Writing Conventions

	R-WISE	WRITE	CONTROL	TOTAL
NH	114	24	110	248
NSH	53	4	38	95
S	49	3	24	76
Total	216	31	172	419

Spring Pass/Fail Data

	R-WISE	WRITE	CONTROL	TOTAL
Pass	84	7	45	136
Fail	132	24	127	283
Total	216	31	172	419

Spring Score Data

	R-WISE	WRITE	CONTROL	TOTAL
2	3	0	12	15
3	36	7	40	83
4	93	17	75	185
Total	132	24	127	283

Spring Subscore Data

Content Organization

	R-WISE	WRITE	CONTROL	TOTAL
NH	99	20	112	231
NSH	31	4	15	50
S	0	0	0	0
Total	130	24	127	281

Language

	R-WISE	WRITE	CONTROL	TOTAL
NH	72	16	80	168
NSH	37	7	30	74
S	21	1	17	39
Total	130	24	127	281

Writing Conventions

	R-WISE	WRITE	CONTROL	TOTAL
NH	64	12	74	150
NSH	29	4	27	60
S	37	8	26	71
Total	130	24	127	281